UNIVERSITY OF MANITOBA

Introduction to CAD/CAE

25.353 Lecture Series

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Outline

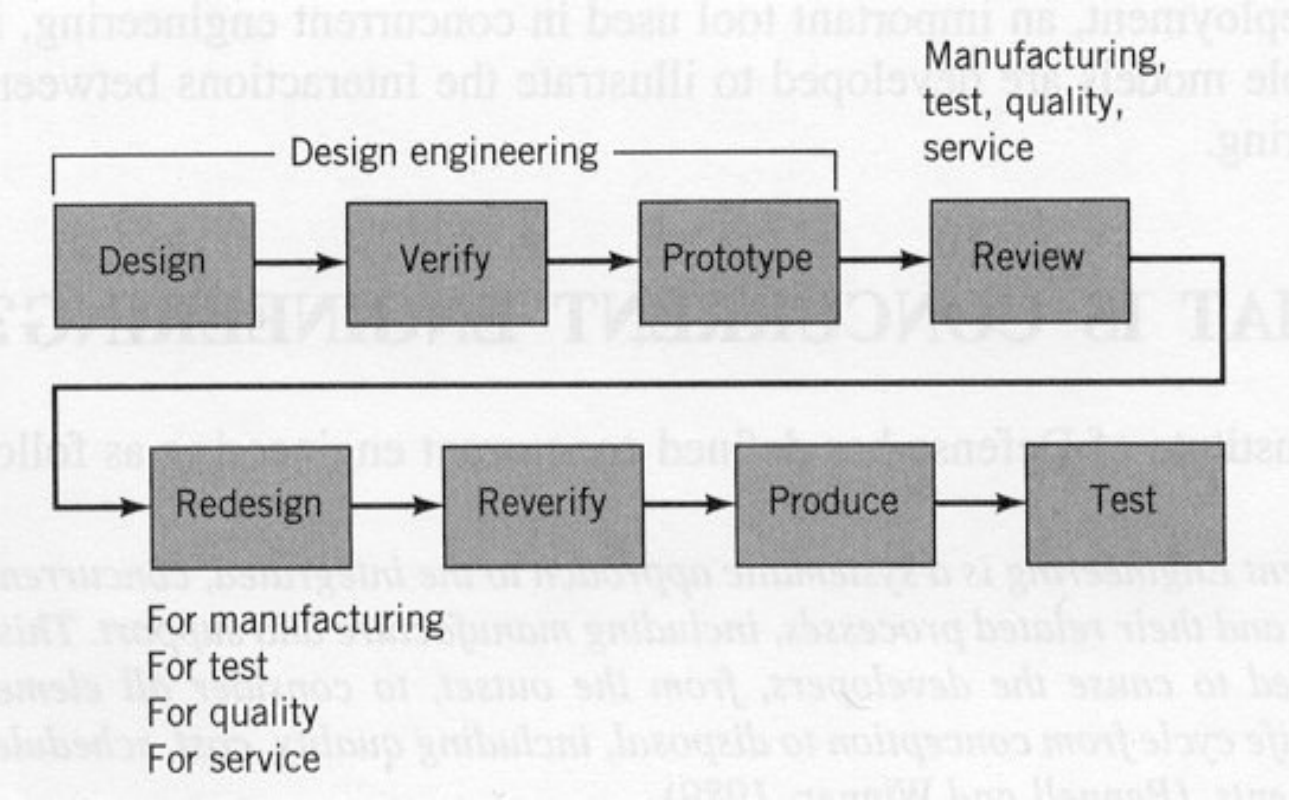
- Traditional Product Design Process
- Concurrent Engineering Design
- What is CAD/CAE?
- What to learn in This Course?
- The Approach to Be Taken

Key Issues of Product Designs over the History

- In the 1970s, cost
- In the 1980s, quality superseded cost
- Today, “better, cheaper, quicker” + “greener” + “more flexible” + …

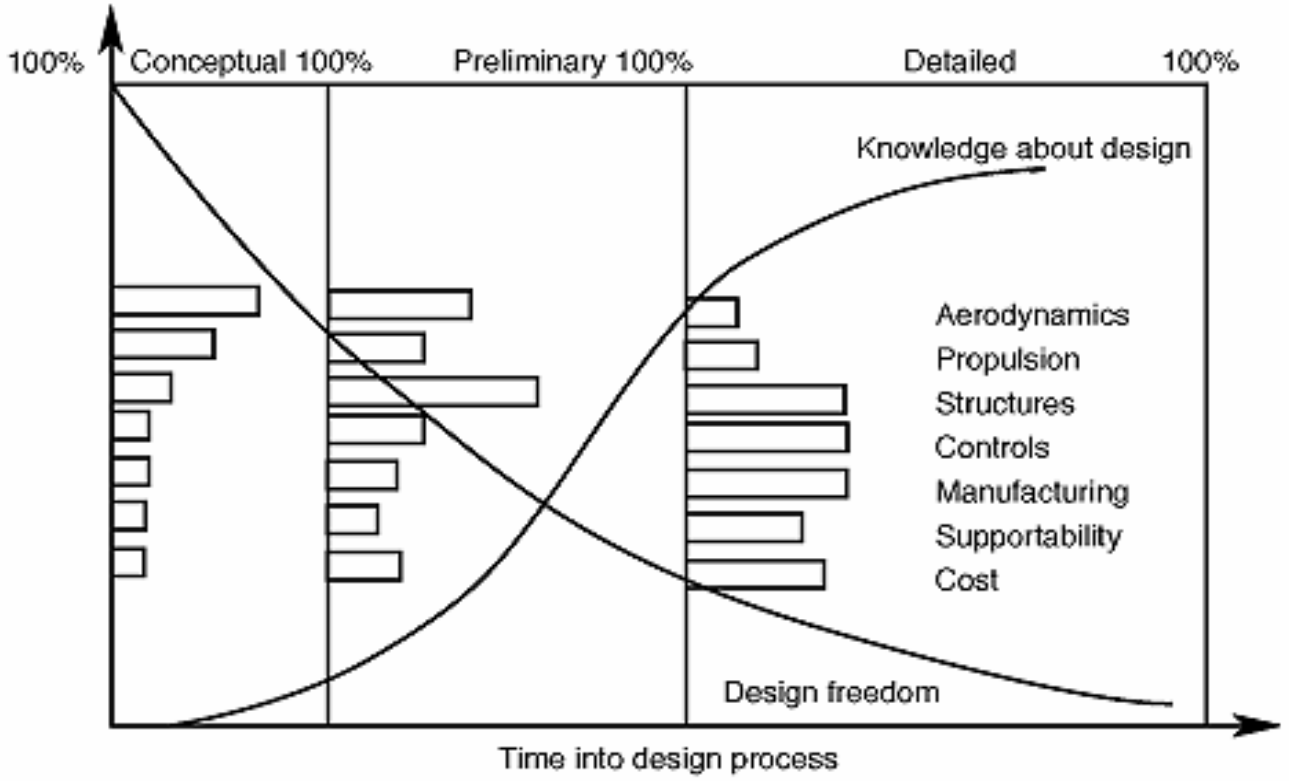
Traditional Engineering Design

The design-make-test-redesign loop



(Nanua Singh, 1996)

Design Freedom and Knowledge



(Daniel Schrage, et al., 1991)

Problems

- Suboptimal design solution
- Costly to change
- Slow to response the market

State-of-the-Art Technologies and Concepts

- Concurrent Engineering (CE)
- **Computer-Aided Design (CAD)**
- Computer-Aided Engineering (CAE)
- Computer-Aided Process Planning (CAPP)
- Computer-Aided Manufacturing (CAM)
- Design for “X” (Manufacturing, assembly, environment, etc.)
- Quality Engineering
- …

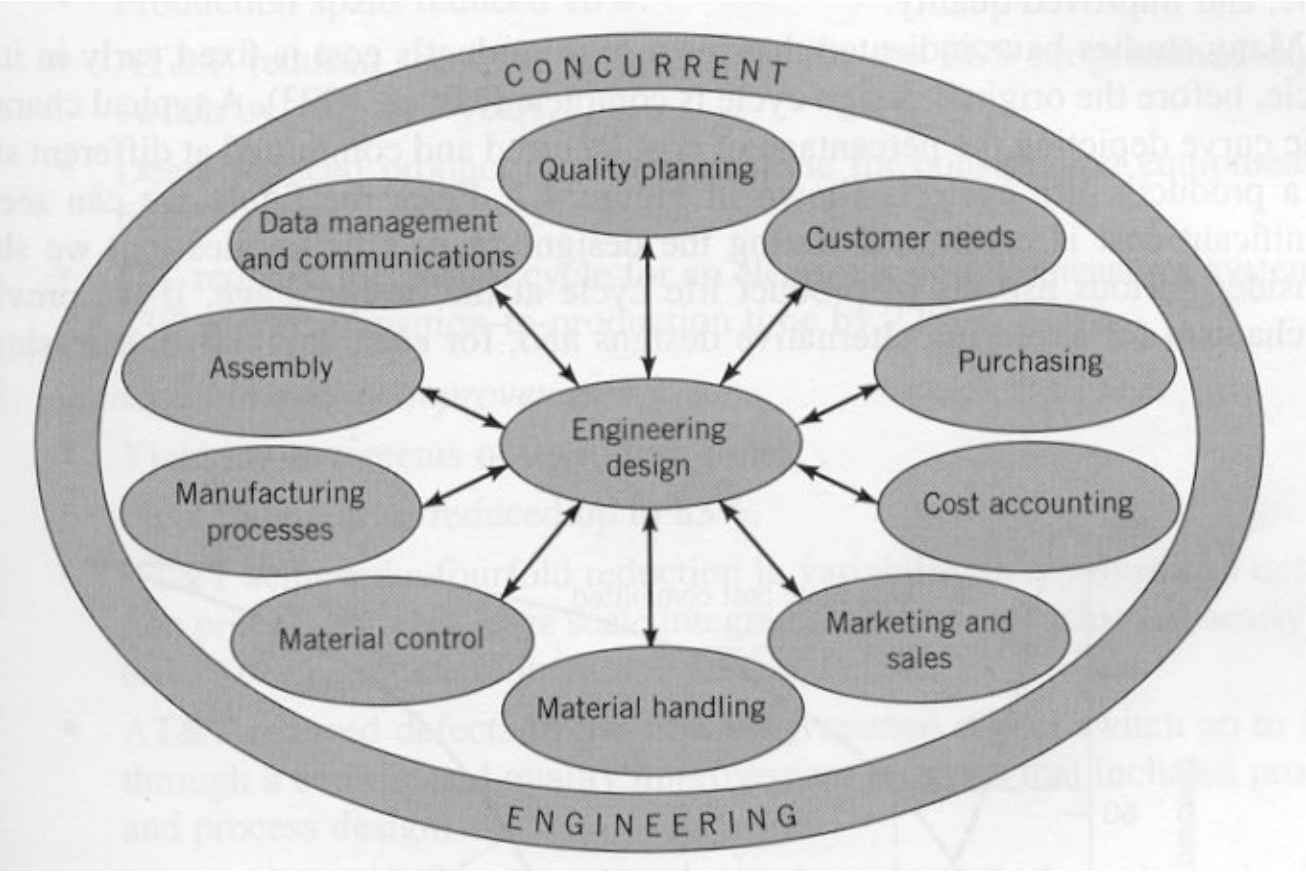
State-of-the-Art Technologies and Concepts (cont'd)

- Robotics
- Manufacturing Planning and Control
- Cellular Manufacturing
- Just-In-Time Manufacturing (JIT)
- Flexible Manufacturing Systems (FMSs)
- Enterprise Integration
- E-business, e-engineering
- ...

Concurrent Engineering (CE)

CE is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception to disposal, including quality, cost, schedule, and user requirements. (Pennell and Winner, 1989)

Concurrent Engineering (contd.)



(Nanua Singh, 1996)

Advantages of CE

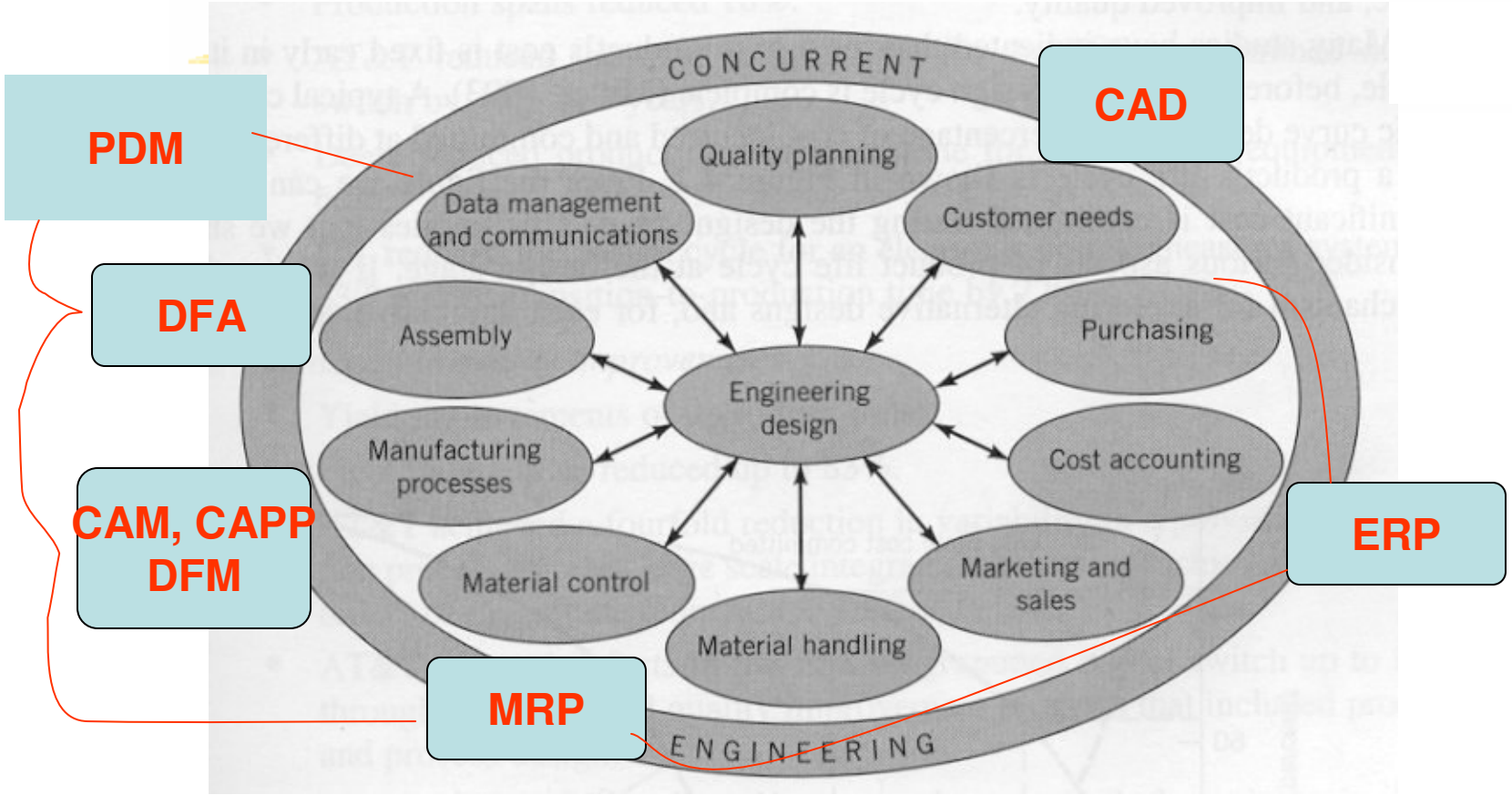
- Product development time reduced up to 60%
- Field failure rates reduced up to 83%
- Engineering changes per drawing reduced up to 15 times
- Early production engineering changes reduced by 15%
- Inventory items stocked reduced up to 60%
- Generally, cost reduced

Challenges of CE

- Characteristics of the design process

  relations among all concerned aspects in the design process
- Volume and Variety of life-cycle knowledge
- The design process involves a large amount of both qualitative and quantitative information

Computer Aided Techniques for CE



DFM(A): Design for Manufacturing (Assembly)

MRP: Materials Requirement/Resource Planning

ERP: Enterprise Resource Planning

PDM: Product Data Management

What is CAD/CAE/CAM?

"CAD/CAM has more potential to radically increase productivity than any development since electricity."

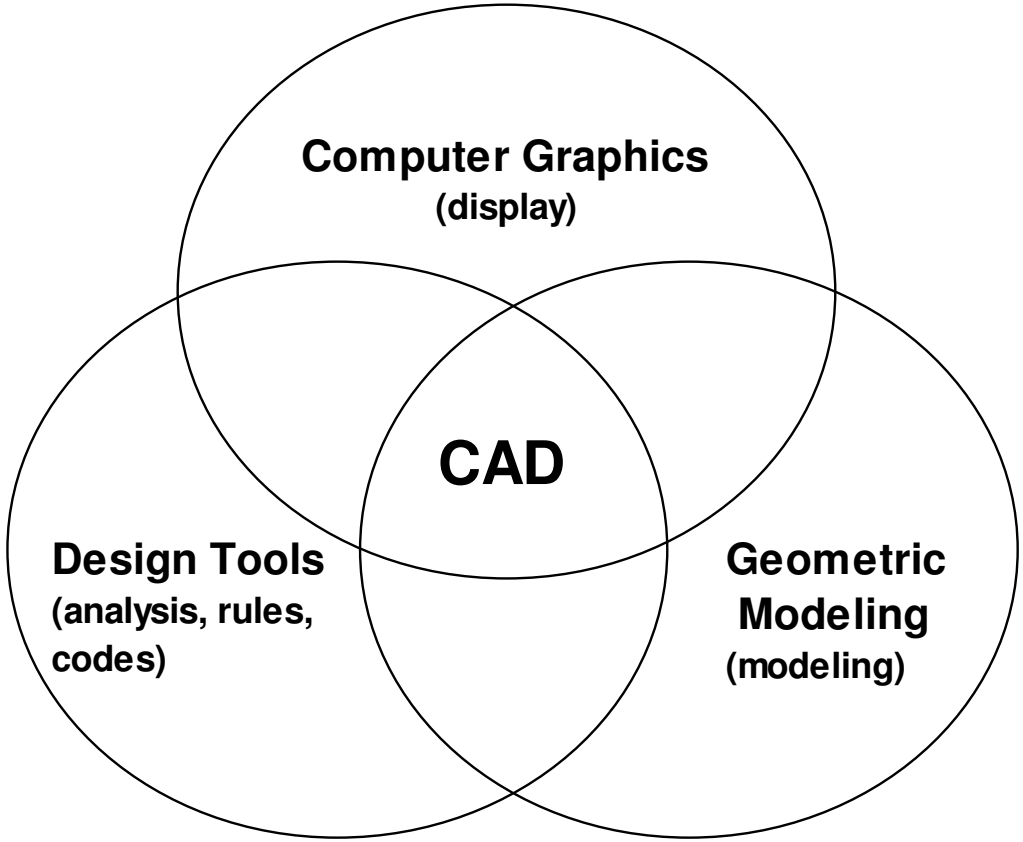
— National Science Foundation's Center for Productivity

What is CAD?

CAD is a technology concerned with the use of computer systems to **assist** in the creation, modification, analysis, and optimization of a design (Groover and Zimmers 1984).

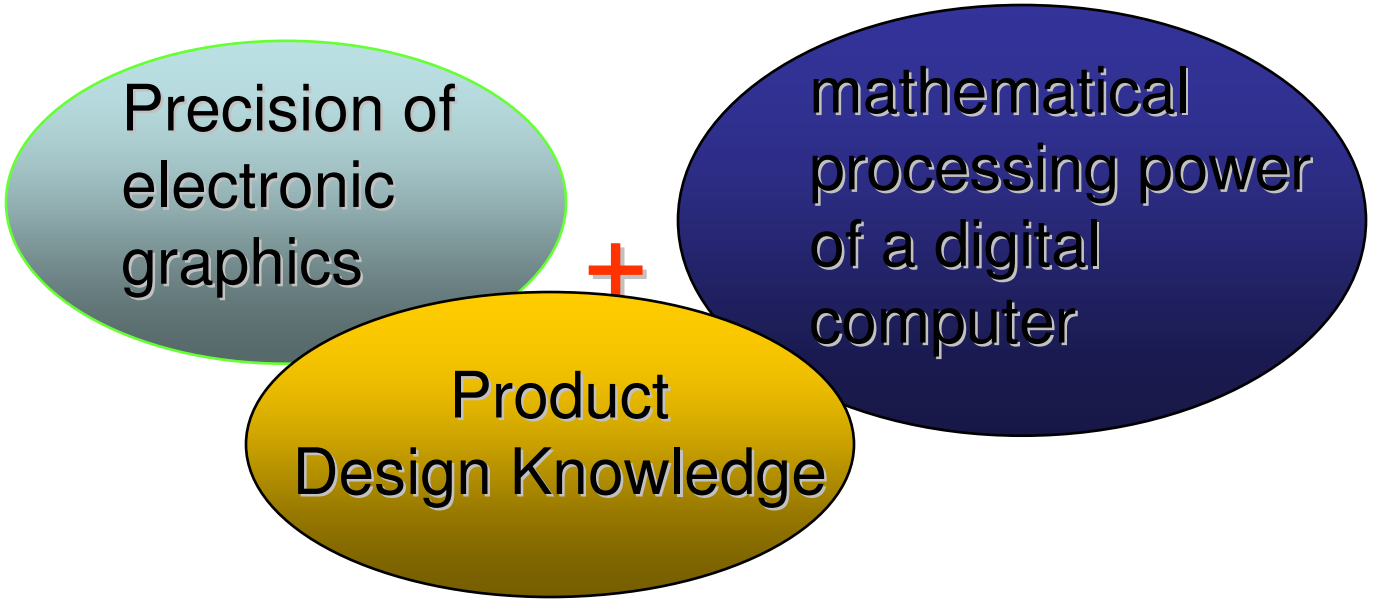
At this point, it is important to emphasize that the computer **does not** change the basic nature of the design process.

Components of CAD



(Zeid, 1991)

Unique Characteristics of CAD



What is CAE?

CAE is a technology concerned with the use of computer systems to analyze CAD geometry, allowing designers to simulate and study how the product will behave so that the design can be validated, refined and, optimized. (Kunwoo Lee, 1999)

Range of CAE

- **Kinematics Analysis**: to determine motion paths and linkage velocities in mechanism.

  Pro/E, Working Model

- **Finite Element Analysis** (FEA): Solid Mechanics analysis (stress/strain), Heat Transfer, Flow, and other **continuous fields**.

  Pro/Mechanica, ANSYS, CATIA, NASTRAN

- **Computational Fluid Dynamics** (CFD): Fluid Simulation.

  Fluent, Phoenix, CFX

Quick Questions

- What is CAD?
- What is CAE?
- What does CAD, CAE, CAM stand for?
- Does CAD necessarily change the conventional design process?
- What are the components of CAD?
- What is CE?
- Why CE?
- How does CAD/CAE/CAM help CE?

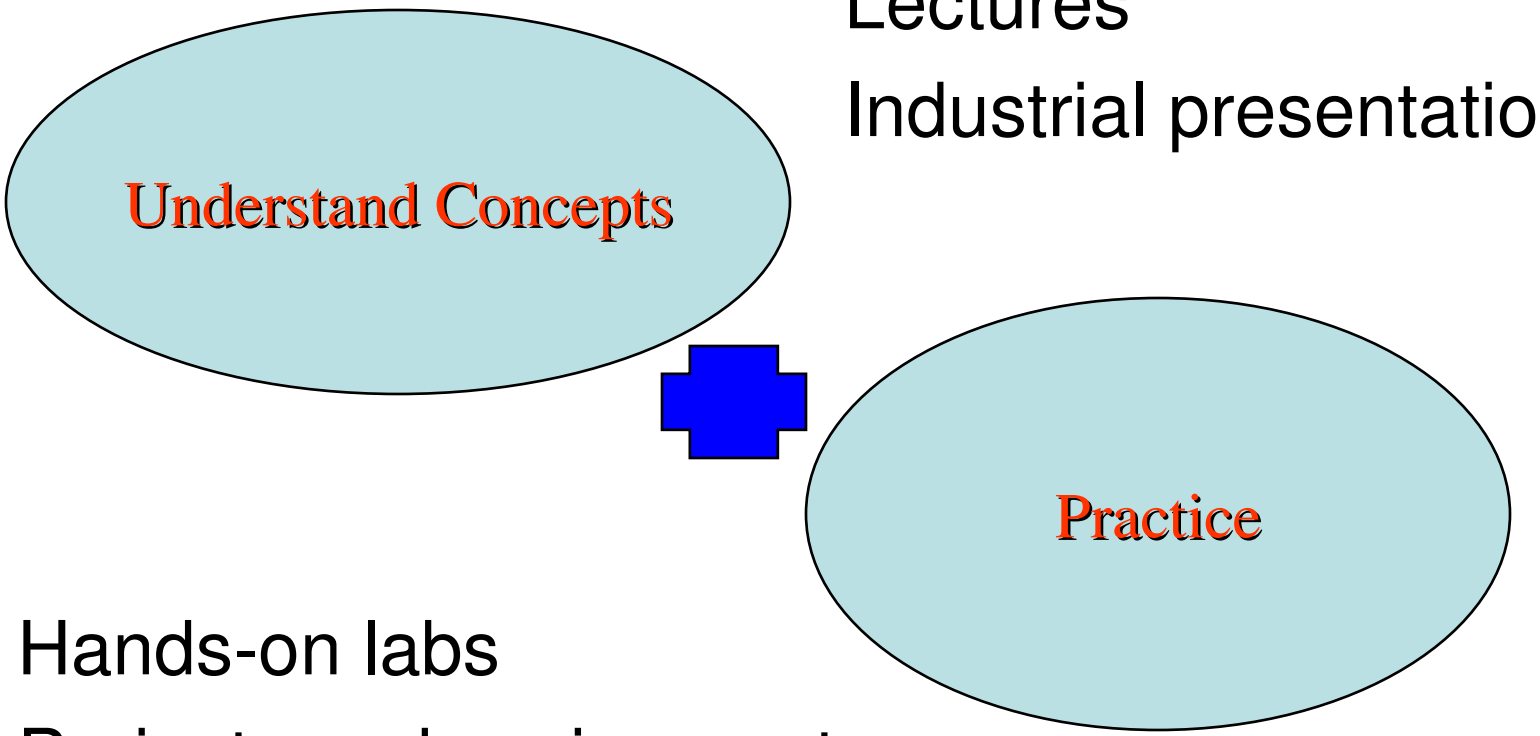
What to learn?

- Computer graphics
- Geometric modeling
- Finite element analysis

Questions to be answered

- What are the fundamental CAD techniques?
- Are you able to model a product using a CAD tool?
- Could you justify your modeling strategy if you are asked to model a complicated surface, e.g. an airfoil?
- What is finite element analysis (FEA)?
- How to perform a FEA?
- Why you think your analysis result is credible?

The Approach for 25.353 (1)



Lectures

Industrial presentations

Hands-on labs

Projects and assignments

The Approach for 25.353 (2)

Learning the fundamental theory of computer graphics and geometric modeling

- Basics of hardware and software
- Geometry transformation, curve and surface generation
- Geometric modeling
- Use of Matlab to generate geometry

Emphasis on the understanding of basic techniques of computer graphics and geometric modeling

The Approach for 25.353 (3)

Introducing the recent advance in Computer-Aided Design and Modeling using a representative commercial CAD system – Pro/Engineer

- Feature-based design and parametric modeling
- Part and assembly modeling

Advanced applications of CAD

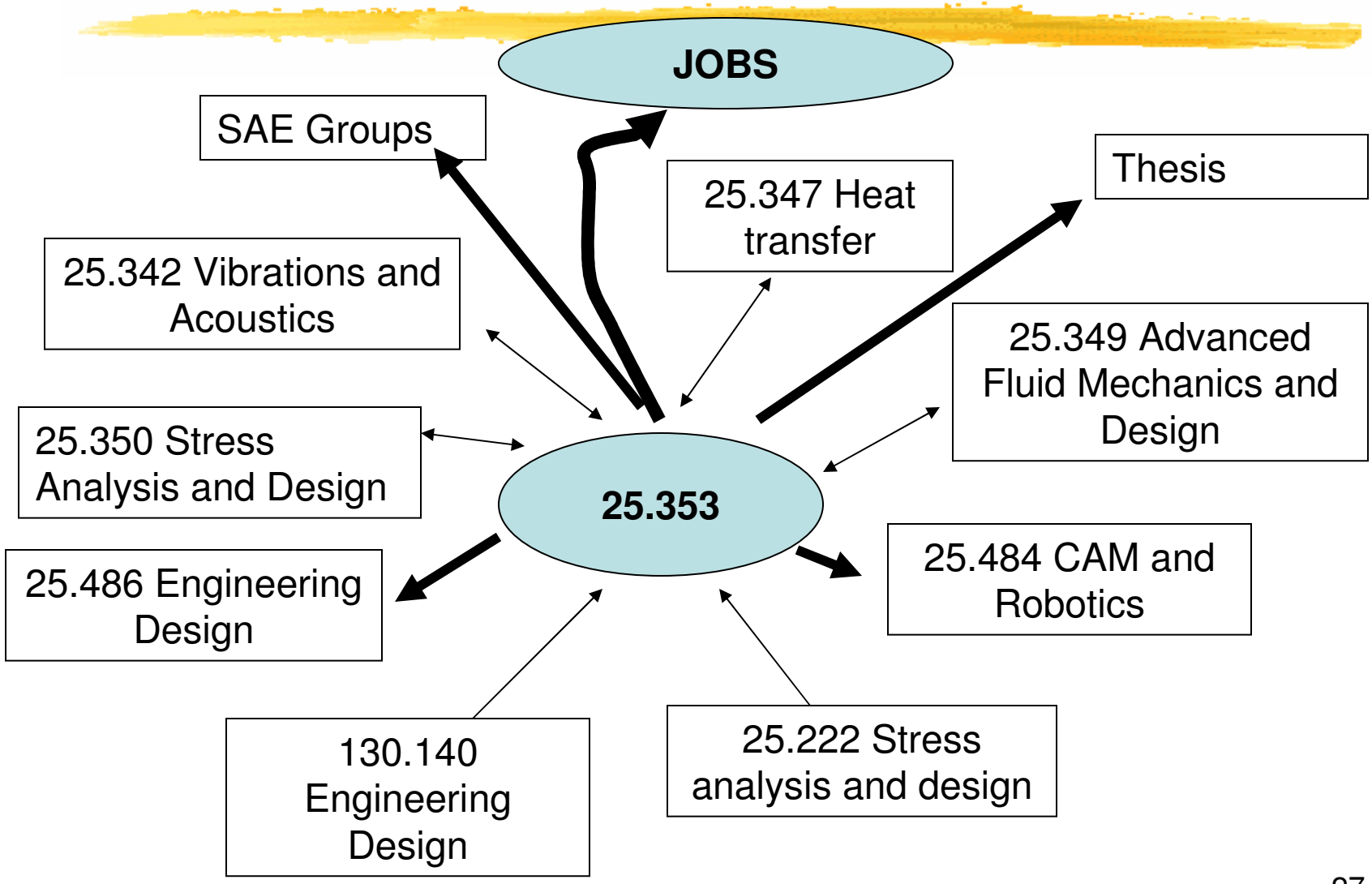
The Approach for 25.353 (4)

Learning basics of finite element analysis (FEA) and the state-of-the-art analysis tool Pro/Mechanica

- Concepts of finite element analysis
- Basic elements and applications

Engineering analysis integrated with CAD and emphasis on problem solving

Link with other courses



Summary

- Traditional/Sequential Design
- Concurrent Engineering/Design
- Definitions of CAD & CAE
- What to learn in this course?
- The approach to be taken